different aspects of brain function and anatomy, including structure, metabolism, and blood flow, respectively, the three modalities are complementary; each makes a unique contribution to the investigation of patients' seizures.

Magnetic resonance imaging exceeds PET and SPECT imaging in its ability to show structural abnormalities. Reported sensitivity and specificity vary. In studies that report the surgical success of seizure control, sensitivities for diagnosis by MRI vary from 80% to 90% for sclerosis due to trauma, infection, or infarction; 90% to 95% for mesial-temporal sclerosis; 90% to 100% for neuronal migration disorder; and 100% for tumor or vascular malformation. High-resolution imaging with three-dimensional volume techniques and 1.5-mm contiguous slices has led to a better detection of cortical dysplasias, hamartomas, and other developmental abnormalities. Three-dimensional data are not necessarily viewed in three-dimensional format, but it allows reformatting of the images in any plane to facilitate distinguishing subtle gyral or cortical abnormalities from normal configurations and to compensate for malalignment of the patient.

For difficult cases in which the electroencephalographic data localize the seizures, but the MRI scan is normal, surface rendering of three-dimensional volume data obtained with MRI has helped radiologists to detect previously occult structural abnormalities. Mesial-temporal sclerosis, the most common cause of temporal lobe epilepsy, is characterized by cell loss and astrogliosis that involves a small portion of the hippocampus. Before advances in spatial resolution, early studies reported MRI to be poorly sensitive to the changes of mesial-temporal sclerosis. The demonstration of atrophy and increased signal in a temporal lobe with high-resolution MRI scans now has a high correlation with successful postsurgical seizure control. Volumetric analysis of MRI images has further improved the sensitivity of MRI in the diagnosis of mesial-temporal sclerosis. Side-to-side differences detected with magnetic resonance–based hippocampal volumetry correlates with cell loss quantified at histology. When electroencephalographic evidence of the start of a unilateral temporal lobe seizure is concordant with predominantly unilateral temporal lobe atrophy by MRI volumetric analysis, there is a greater than 90% chance of an excellent surgical outcome compared with 50% surgical success when volumetric evidence for unilateral atrophy is absent on MRI. The identification of a lesion on MRI in extratemporal areas also correlates with successful postsurgical seizure control.

Functional MRI uses ultrafast scanning techniques to scan patients while they are doing a task that is known to activate specific cortical regions, for example, the sensorimotor cortex. The technique is used to define the relationship of an epileptogenic pathologic substrate (such as tumor) to functionally eloquent cortex before surgical resection and thereby to avoid unacceptable postsurgical deficits.

The structural abnormalities seen with MRI correlate highly with the epileptogenic zone, but are not definitive. Therefore, MRI cannot be used alone. The epileptogenic zone is highly likely to be within a zone of altered metabolism or blood flow as seen with PET and SPECT, respectively. Both modalities have a relatively high sensitivity—PET, 70% to 80% for interictal scans; SPECT, 73% and 97% for peri-ictal and ictal scans, respectively—and moderate specificity for the diagnosis of temporal lobe epilepsy. Lower sensitivities are seen in patients with extratemporal seizures. Although metabolism and blood flow increase during ictal events and decrease interictally, the detection of metabolic changes by PET with the use of fludeoxyglucose F 18 is known to be more sensitive. Although the spatial resolution for modern clinical PET scanners is typically 5 to 7 mm, the added advantages of wider availability, reduced cost, and greater feasibility of ictal scanning with SPECT after administering hexamethyl-propyleneamine oxime (HMPAO) make this modality the more practical tool. Typical resolution for a modern three-head SPECT camera is 6 to 8 mm. Truly ictal studies are possible with HMPAO-SPECT studies because there is rapid uptake of the radiotracer but little washout, so the functional image represents activity during the time of administration and remains bound to the brain for several hours, which facilitates administering the radiotracer at ictus and scanning as long as four hours later. Seizure localization is most reliable when the radiotracer is administered early at the start of seizures and when a seizure does not propagate or does so minimally.

BRIAN W. CHONG, MD
DAVID K. SHELTON, MD
Sacramento, California

REFERENCES

Jack CR Jr: Epilepsy: Surgery and imaging. Radiology 1993; 189:635-646

Spencer SS: The relative contributions of MRI, SPECT, and PET imaging in epilepsy. Epilepsia 1994; 35(suppl 6):S72-S89

Valk PE, Laxer KD, Barbaro NM, Knezevic S, Dillon WP, Budinger TF: High-resolution (2.6-mm) PET in partial complex epilepsy associated with mesial temporal sclerosis. Radiology 1993; 186:55-58

Imaging of Appendicitis

MOST PATIENTS WITH acute appendicitis have classic clinical findings and are treated surgically. About a third of patients have atypical or confusing clinical findings and often require radiologic imaging. Abdominal radiographs and barium enema have been used in the past to aid in the diagnosis of acute appendicitis. Recently, the use of real-time ultrasonography and computed tomography (CT) has been advocated in patients with this possible diagnosis. The ultrasound examination involves graded compression in the right lower quadrant and especially in the area of maximal tenderness. Because of advances in technology and familiarization with expected sonographic findings, a normal appendix is frequently visualized, excluding the diagnosis of appendicitis. Diagnostic criteria for acute appendicitis in both children and adults include a distended appendix that is greater than 6 mm in diameter, lacks compressibility and peristalsis, and is constant in shape. Findings that are strongly suggestive include pericecal inflammation or abscess. Visualization of an appendicolith increases the specificity. In cases of appendiceal perforation, the appendix itself may be difficult, if not impossible, to visualize. A pericecal loculated fluid collection suggests perforation, whereas free intraperitoneal fluid is not a predictor of perforation.

With color Doppler ultrasonography, increased blood flow can be seen in areas of inflammation. Although this technique can increase observer confidence, it does not increase the sensitivity in detecting acute appendicitis. Recent studies have shown the use of sonography for the diagnosis of appendicitis to have a sensitivity of 76% to 100%, a specificity of 89% to 97%, and an accuracy of 83% to 97%. The ultrasound diagnosis of appendicitis is somewhat limited by the presence of obesity, ascites, and severe abdominal pain and can be more difficult if an appendix is retrocecal. Ultrasonography, however, is useful in evaluating the abdomen and pelvis for other disease if scanning of the right lower quadrant is not diagnostic for appendicitis. In children, other possible disorders that can be revealed with ultrasonography include mesenteric adenitis, ileitis, intussusception, Crohn's disease, Burkitt's lymphoma, foreign body, and neutropenic colitis.

Computed tomography has also been used to evaluate atypical clinical findings of appendicitis and can be highly specific even without the use of intravenous or oral contrast media. Computed tomographic criteria include the visualization of an abnormal appendix with fat stranding in the pericecal area or an appendicolith with a right lower quadrant abscess or phlegmon. The sensitivity, specificity, and accuracy for the CT diagnosis of acute appendicitis range from 87% to 98%, 83% to 97%, and 83% to 97%, respectively. Computed tomography can be used to detect complications of appendicitis such as hepatic abscess, small bowel obstruction, and mesenteric venous thrombosis and to evaluate concurrent disorders. It is also useful in the guidance of percutaneous appendiceal abscess drainage procedures.

Although there is a small false-negative and false-positive rate for the diagnosis of appendicitis using either ultrasonography or CT, both modalities can be extremely useful. Ultrasonography may be most beneficial in children and young women because of the lack of ionizing irradiation, lower cost, and positive predictive value. Equipment is portable if necessary. In women of childbearing age, graded compression ultrasonography in conjunction with an endovaginal ultrasonogram is useful for evaluating acute gynecologic disorders. Computed tomography is advantageous in that it is tolerated by sick patients, is not operator-dependent, and the results are not affected by the amount of bowel gas or abdominal pain.

REBECCA HULETT, MD
Tucson, Arizona

REFERENCES

Balthazar EJ, Birnbaum BA, Yee J, Megibow AJ, Roshkow J, Gray C: Acute appendicitis: CT and ultrasound correlation in 100 patients. Radiology 1994; 190:31-35

Curtin KR, Fitzgerald SW, Nemcek AA, Hoff FL, Vogelzang RL: CT diagnosis of acute appendicitis: Imaging findings. AJR Am J Roentgenol 1995; 164:905-909

Quillin SP, Siegel MJ: Appendicitis: Efficacy of color Doppler sonography. Radiology 1994; 191:557-560

Spiral and Ultrafast Computed Tomography for Noninvasive Cardiac Imaging in Children

CONGENITAL HEART DISEASE is a serious health problem in the United States, affecting about 8 of 1,000 newborns. With the recent dramatic improvements in postoperative survival of infants with even the most serious and complex congenital cardiac malformations, emphasis has been placed on improving cardiac function, neurologic outcome, and the quality of life. Imaging studies play an important role in the management of these patients.

During the past decade, the need for cardiac catheterization with projectional angiocardiography has decreased with the use of less invasive cross-sectional imaging techniques such as echocardiography and magnetic resonance imaging. Computed tomography (CT) combines high spatial and contrast resolution with tomographic imaging, eliminating the superimposition of complex cardiac anatomy and surrounding lung and bony chest wall. The recent development of spiral and ultrafast (electron beam) CT techniques has extended its application to cardiovascular imaging (CT angiocardiography) with less motion artifact due to heartbeat and respirations. In adult abdominal and peripheral vascular disease, CT angiography has yielded results comparable to those of projectional angiography, with less radiation exposure, reduced requirements for contrast material, and no need for invasive catheterization of the vascular system. In the chest, CT angiography is most useful in the diagnosis of pulmonary embolism and in congenital heart disease, where there is a need for exactly delineating complex cardiovascular anatomy.

In infants and children, because of their small size, the entire thorax can be covered with spiral CT in 20 to 30 seconds during peak contrast enhancement given through a peripheral vein. Motion is further reduced by having older cooperative children hold their breath during the scan. Young children can be scanned successfully during quiet respiration, and sedation is less frequently needed because of the rapid acquisition time of the CT data. Imaging data are initially reconstructed as axial slices, familiar from conventional CT. Because the data are collected from a large volume of tissue rather than a slice at a time, they can be subsequently reconstructed and viewed on a computer work station from different angles in user-selected cross-sectional planes and three-dimensional renditions best suited to display complex cardiovascular relationships, without the need to administer additional contrast media.

Respiratory and cardiac motion can be further suppressed by means of ultrafast (electron beam) scanning. Slice acquisition time is about 100 milliseconds, and, when using the dynamic imaging mode, the images are virtually motion-free even in dyspneic or crying children. Multislice bolus tracking (flow) techniques can be used to visualize hemodynamic events in real time and to calculate shunt fractions. Cardiac gating is used to link image acquisition to events in the cardiac cycle, allowing the reconstruction of multislice cine sequences, which are used to evaluate regional ventricular wall motion and to calculate